8325
.23
LIBRARY
CURRENT SERIAL RECORD
MAY 24 1944
U. S. DEPARTMENT OF AGRICULTURE

VOL. XXVII JANUARY 1943 NO. 1

Entered as second-class matter September 14, 1934, at the post office at Rio Piedras, under the Act of August 24, 1912

THE JOURNAL OF AGRICULTURE

of the

UNIVERSITY OF PUERTO RICO

In continuation of The Journal
of the Department of Agriculture of Puerto Rico

Chemical Changes of the Papaya Plant During Development, with Special Reference to its Proteolytic Activity

By C. F. ASENJO, D. H. COOK, M. DEL C. DE FERNANDEZ, and L. A. ALVAREZ

The Effect of Staking and Pruning on Tomato Plants

By ARTURO RIOLLANO

Studies of the Shade Requirements of Vanilla

By ERNESTO HERNANDEZ MEDINA

Published by

THE AGRICULTURAL EXPERIMENT STATION

of the

UNIVERSITY OF PUERTO RICO

Rio Piedras, P. R.

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF PUERTO RICO
Río Piedras, P. R.

Jaime Benítez, M.A. Ll.M. ----------	**Chancellor**
Luis Stéfani. M.S. ----------	**Vice-Chancellor**

Station Staff

Arturo Roque, M.S.	**Director**
R. Colón Torres, M.S.	Ass. Director
E. del Toro, Jr. (1)	Administrative Assistant
B. G. Capó, Ph.D.	Biometrician
M. R. García	Finance Officer
Soils:	
J. A. Bonnet, Ph.D.	Soil Chemist, Head of Department
A. Riera, B.S.	Assistant Chemist
R. Rodríguez Torrent, B.S. (2)	Associate Soil Chemist
Phytotechnics:	
Arturo Riollano, M.S.	Agronomist, Head of Department
J. Guiscafré Arrillaga, M.S. (2)	Associate Agronomist
F. Méndez, B.S.	Asso. Agronomist in Charge Station Farm
E. Molinary Saliés, B.S. (1)	Assistant Horticulturist
P. Richardson Knutz, B.S.	Associate Agronomist
J. P. Rodríguez, B.S.	Associate Agronomist
M. A. Díaz, B.S.	Assistant Agronomist
L. A. Gómez, B.S.	Assistant Agronomist
Economics (Agricultural):	
R. Colón Torres, M.S.	Head of Department
F. de Jesús, M.S.	Associate Economist
S. Díaz Pacheco, B.B.A. (1)	Associate Economist
J. J. Serrallés, Jr., M.S.	Associate Economist
Mariano Roses, M.S. (2)	Assistant Economist
M. Vélez, B.B.A.	Assistant Economist
Martín Hernández, B.S.	Acting Assistant Economist
J. O. Morales, B.S. (1)	Assistant Economist
Manuel Piñero, B.S.	Acting Assistant Economist
J. D. Rivera Anaya, B.S.	Assistant Economist
P. B. Vázquez Calcerrada, B.S.	Acting Assistant Economist
Entomology:	
G. N. Wolcott, Ph.D.	Entomologist, Head of Department
L. F. Martorell, Ph.D.	Associate Entomologist
F. Sein, Jr., B.S.	Associate Entomologist
Plant Physiology:	
----------	Plant Physiologist, Head of Department
F. J. Ramírez Silva, M.S.	Associate Chemist
Miss A. Gauthier Roig, B.S.	Assistant Plant Physiologist
Phytopathology:	
L. A. Alvarez, M.S.	Phytopathologist, Head of Department
José Adsuar, B.S.	Associate Phytopathologist
Plant Breeding:	
----------	Plant Breeder, Head of Department
A. Acosta Matienzo, M.S. (2)	Assistant Plant Breeder
Juan E. Veve, B.S.	Acting Assistant Plant Breeder
R. Vizcarrondo, B.S.	Assistant Plant Breeder
Engineering:	
M. L. Vicente, C.E. M.E.	Engineer
Chemistry:	
Rafael Arroyo, B.S. S.E.	Chemist, Head of Department
H. Cruz Monclova, M.S. Ch.E. (1)	Associate Chemist
J. H. Ramírez, B.S.	Associate Chemist
Leonardo Igaravídez, B.S.	Assistant Chemist
Fernando Marrero, B.S. S.E. (1)	Assistant Chemist
Miss Angeles Mayoral, B.S.	Junior Chemist
Animal Husbandry:	
Frank Picó, M.S.	Animal Husbandman, Acting Head of Dept.
F. J. Marchán, M.S. (2)	Assistant Chemist
C. M. Muñiz, D.V.M.	Associate Veterinarian
Herbert R. Gómez, B.S. (1)	Acting Assistant Animal Husbandman
Animal Production Sub-Station, P. O., La Plata, Aibonito:	
Enrique S. Vilella, B.S.	Assistant Animal Husbandman
Isabela Sub-Station, P. O. Isabela:	
L. A. Serrano, B.S.	Agronomist in Charge
C. L. Clavell, B.S. (2)	Assistant Agronomist
R. K. Giles, B.S.	Acting Assistant Agronomist
F. J. Juliá, B.S. (2)	Assistant Agronomist
Romualdo A. Irizarry Bulla, B.S.	Acting Assistant Agronomist
Plant Propagation Sub-Station, P. O., Río Piedras:	
J. S. Simons, B.S.	Assistant Agronomist in Charge
Library:	
Jorge Rivera Ruíz, B.L.S.	Librarian

(1) On leave.
(2) Military leave.

The Journal of Agriculture of the University of Puerto Rico

In continuation of The Journal of the Department of Agriculture of Puerto Rico

Published by The Agricultural Experiment Station, Río Piedras, P. R.

Published Quarterly: January, April, July and October of each year.

VOL. XXVII JANUARY, 1943 NO. 1

CHEMICAL CHANGES OF THE PAPAYA PLANT DURING DEVELOPMENT, WITH SPECIAL REFERENCE TO ITS PROTEOLYTIC ACTIVITY

by

C. F. Asenjo, D. H. Cook, M. del C. de Fernández, and L. A. Alvarez, from the Department of Chemistry of the School of Tropical Medicine and the Department of Phytopathology of the Agricultural Experiment Station of the University of Puerto Rico

Introduction

The papaya plant (*Carica papaya* L.) attains full maturity in approximately thirteen months of growth, when it bears fruit. During this period of development, several chemical changes take place in the plant. The present investigation was undertaken principally to determine the general trend of variation in the proteolytic activity of the various parts of the plant throughout this period of development. However, other data were collected at the same time, including that referring to the variation in moisture content, hydrogen ion concentration, and total nitrogen. As no data of this nature have previously been recorded, we have thought the same may be of use to those engaged in the study of the papaya plant. For this reason, these data have been included in the present paper, together with those finding related to the distribution of proteolytic activity throughout the plant.

Materials and methods

In the present investigation, the following material and methods were used.

Plant material. The native variety of papaya was utilized. Seeds were sterilized and planted in a greenhouse. The seedlings were then transplanted into pots and, on attaining an age of approximately three months, were in turn placed out in the open. Samples for analysis were taken as recorded in Table I.

TABLE I

Schedule Followed In Collecting Samples for Analysis

Month and year	Age in days after planting seed	Sample of	Amount of samples collected
Sept. 1940	0	Seeds	50 gm.
" 1940	3	"	50 "
" 1940	6	"	50 "
" 1940	13	Whole seedling	50 seedlings
Oct. 1940	43	Whole plant	25 plants
Nov. 1940	73	" "	5 "
Dec. 1940	103	" "	2 "
Jan. 1941	133	" "	1 "
Feb. 1941	163	" "	1 "
Mar. 1941	193	" "	1 "
Apr. 1941	223	" "	1 "
May 1941	253	" "	1 "
June 1941	283	" "	2 "
July 1941	313	" "	1 "
Aug. 1941	343	" "	2 "
Sept. 1941	373	" "	1 "
Oct. 1941	403	" "	1 "

All of the samples were collected early in the morning and immediately sent to the laboratory, where they were placed in cold storage at a temperature of about 8°C. Samples were always utilized within the following twenty-four hours.

Total moisture. Total moisture was determined in the seed, root, stem, leaf, and fruit by placing samples of these various parts in an oven at a temperature of 110°C, until constant weight was attained. The loss in weight was taken as an index of the moisture content of each sample.

Expression of juice. The tissues were thoroughly ground with a small amount of washed quarz in a porcelain mortar and the paste, thus formed, squeezed in a piece of cheesecloth until all the juice was expressed. The juice obtained was used immediately.

Hydrogen ion concentration. The hydrogen ion concentration of the juice was determined with a Leeds and Northrup glass electrode meter.

Milk clotting activity. The milk clotting activity of the juice was one of the indexes used to measure proteolytic activity and the method followed in this determination, was that of Balls and Hoover (2). Results obtained in these milk tests were expressed in milk clotting units equivalent to the amount of enzyme required to clot 5 cc. of the standard milk preparation in one minute at 40°C.

Hydrolysis of gelatin. Another index used to measure proteolytic activity was the ability shown by the juice to hydrolyze gelatin; the method followed was the formol titration. A two per cent gelatin solution pH 5 was used as substrate. To 5 cc. of this solution 1 cc. of juice was added. One cc. of this mixture was taken for the initial titration. One cc. of 40 per cent formaldehyde was added to each volume of mixture to be titrated. The indicator used was a solution of 0.2 per cent phenolthalein in 50 per cent alcohol. The incubation period lasted 20 hours at a temperature of 40°C. The strength of the sodium hydroxide solution used for titration was of 0.01N.

Nitrogen content of the tissues examined. All nitrogen determinations were performed in accordance with the Kjeldahl-Gunning-Arnold method (1).

Experimental Results

The seed. No measurable amount of proteolytic activity was detected in the seeds before or during the germination period. The nitrogen content of the seed, as planted, was 41.5 mg. per gram of dry seed; samples taken during the thirteen days before germination averaged 44.4 mg. of nitrogen per gram of dry seed. For other determinations performed on the seed, see Table II.

The leaf. Proteolytic activity appeared first in the leaf and then in other parts of the plant as can be seen in Tables III, IV, and V. Samples collected forty-three days after planting the seed showed, on dry basis, a milk clotting activity of 1.80 units per gram and a formol titration of 15 cc. of 0.01N NaOH. The peak of proteolytic activity in the leaf, as indicated both by the milk clotting and formol titration, was reached about the 133rd day after planting of the seed. These values were 11.16 milk units and 56.16 cc. 0.01N NaOH, respectively, on dry basis per gram. From this date on, proteolytic activity of the leaf consistently decreased. The last test performed on the 403rd day gave 4.68 units and 13.61 cc.

0.01N NaOH per gram of dry leaf for the milk clotting test and formol titration, respectively. Nitrogen content of the leaf averaged 42.6 mg. per gram of dry leaf. The highest content was observed on the 253rd day, 49.9 mg., while the lowest, 35.6 mg., was recorded on the 193rd day. For other determinations performed on the leaf, see Tables II, III, and VI.

The stem. Milk clotting activity did not appear in the stem until the 73rd day. This initial activity, as well as that exhibited all throughout the experimental period, was much lower than in the leaf. Average clotting per gram of dry tissue was 2.48 milk units, while the formol titration was 8.18 cc. of 0.01N NaOH. The peak in milk clotting activity, 5.09 units, was reached on the 133rd day. On other hand, formol titration did not show a maximum until the 283rd day when a titration of 13.21 cc. of 0.01N NaOH per gram of dry stem was recorded. Average nitrogen content was 13.7 mg. per gram of dry tissue. A maximum of 20.8 mg. was recorded on the 253rd day and a minimum of 6.6 mg. on the 403rd day. For other data related to the stem, see Tables II, IV, and VI.

The root. Of the various parts of the papaya plant, the root showed the lowest milk clotting activity, although its gelatin hydrolyzing power was the same as that of the stem. Its average milk clotting activity and formol titration per gram of dry tissue were 1.39 milk units and 8.12 cc. of 0.01N NaOH, respectively. The peak in milk clotting activity, 3.43 units, was reached on the 283rd day; the peak in formol titration, on the same day with a value of 17.50 cc. of 0.01N NaOH. Average nitrogen content of the root was 14.3 mg. per gram of dry tissue; its maximum content was recorded on the 223rd day with 19.8 mg. and the lowest on the 373rd day, with 8.5 mg. per gram of dry tissue. For other data on this part of the plant, see Tables II, V, and VI.

The fruit. For the purpose of this study the fruit was divided into two parts: the rind and the pulp. It is well known that the rind contains the largest amount of the latex present in the fruit, while the pulp contains practically none. The fruit was collected at the same time from two different trees, both about thirteen months old. That fruit belonging to the younger inflorescence at the top was small and undeveloped; that from the older inflorescences at the bottom was well developed and medium ripe. Tables VII, VIII, IX, and X, record the inflorescences from the seventh to the first; the seventh being the younger at the top and the first being the older at the bottom of the tree.

(a) *The rind.* The average proteolytic activity of the rind per gram of dry tissue was 36.2 milk units and 26.4 cc. of 0.01N NaOH. Maximum

activity was observed in the fruit belonging to the third inflorescence with values of 94.1 milk units and 36.1 cc. of O.01N NaOH, respectively, for milk clotting and formol titration. The fruit from this inflo- can be seen from Table VIII. The average nitrogen content of the rind was of 29.9 mg. per gram of dry tissue. For other data, see Tables VII, VIII and X.

(b) *The pulp.* The pulp of the fruit showed a much lower proteolytic activity than the rind, both when such activity was measured by the milk clotting test as well as by formol titration. Milk clotting activity of the pulp was nearly one-tenth that of the rind (36.2 units against 3.3 units per gram of dry tissue). Formol titration of the pulp was about a one-third that of the rind (26.4 cc. against 9.9 cc. O.01N NaOH per gram of dry tissue). The milk clotting power of the pulp from the second and first inflorescences was zero. On the other hand, its gelatin hydrolytic activity remained quite uniform throughout, showing an average of 9.9 cc. of O.01N NaOH per gram of dry tissue. The average nitrogen content of the pulp was 14.9 mg. per gram of dry tissue, that is, about half the average nitrogen content of the rind. As in the rind, this nitrogen content also had a tendency to decrease with the age of the fruit. For other data on the pulp, see Tables VII, IX, and X.

Discussión

Outside of the observations made by Balls, Thompson and Jones [3] to the effect that the entire papaya plant, aside from the roots, contained considerable enzyme activity, no other investigation, as far as we know, has been conducted along these lines.

The results obtained by us confirmed the observations of the above mentioned investigators and showed, furthermore, that milk clotting activity made its appearance first, in the leaf of the young plant and later, in the stem and root. The two parts of the plant which at all times showed a high proteolytic activity were the green leaves and the green fruit rind. Whether the formation of papain is closely connected with the presence of chlorophyl we are not in a position to say; however, it is interesting to note the close association that exists between these two substances in the different parts of the papaya plant.

In the leaf, at least, there was a definite variation in proteolytic activity during the first thirteen months of growth. Such activity reached its maximum value on the 133rd day after planting of the seed, but decreased consistently thereafter until the end of the experiment. The same variation was noticed, to a lesser extent, in the stem and in the root.

It must be remembered that these results are subject to considerable variation due to the use of single tree samples for each set of determinations. Lack of planting space made it necessary to take single trees for analysis in such a long time experiment. We feel, however, that in spite of individual variations, these results show definite trends in the distribution and activity of the substances measured.

Summary

1. All parts of the papaya plant, with the exception of the seed, showed varying degrees of proteolytic activity.

2. Milk clotting activity appeared first in the leaf and later, in the stem and root.

3. The largest amount of proteolytic activity was concentrated in the green fruit rind and, in decreasing quantities, in the leaf, fruit pulp, stem, and root.

4. In the leaf and, to a lesser extent, in the stem and root, a definite variation took place in proteolytic activity during the thirteen initial months of growth. Maximum activity was reached between the fourth and ninth months.

5. Data have been collected regarding the moisture, hydrogen ion concentration, and nitrogen content of the various parts of the papaya plant during its initial thirteen months of growth.

SUMARIO

1—Todas las partes de la planta de la papaya, con excepción de la semilla, demostraron poseer distintos grados de actividad proteolítica.

2—La actividad proteolítica apareció primero en la hoja y más tarde en el tallo y las raíces.

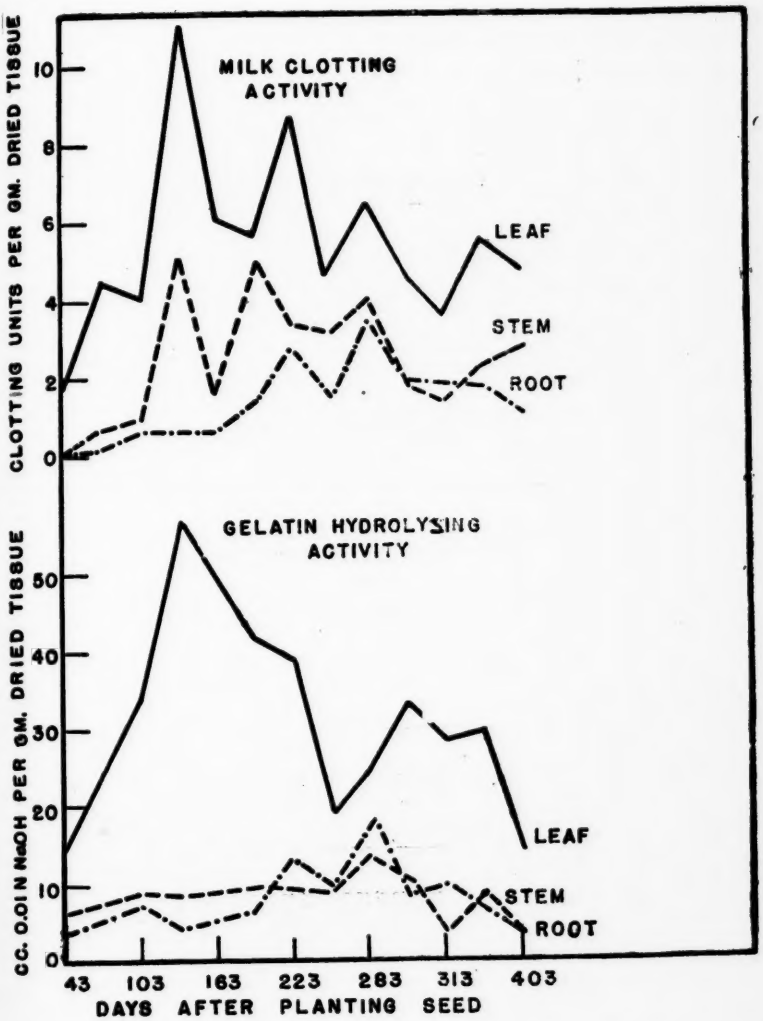
3—La actividad proteolítica estaba concentrada en mayor grado en la corteza de la fruta verde y, en cantidades menores, en las hojas, la pulpa de la fruta, el tallo y las raíces.

4—En las hojas y, en menor grado, en el tallo y las raíces, se produjo una variación definida en la actividad proteolítica durante los 13 meses iniciales de crecimiento. La actividad máxima se alcanzó entre los 4 a 9 meses.

5—Se han tomado datos en cuanto al contenido de humedad, variación en el pH y el contenido de nitrógeno de las distintas partes de la planta durante los 13 primeros meses de su desarrollo.

Literature Cited

1. Anonymous. Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists. 4th ed. p. 25. 1935.
2. Balls, A. K. Jour. Biol. Chem. **121**: 737-745. 1937.
3. Balls, A. K., R. R. Thompson, and W. W. Jones. Ind. and Eng. Chem. **32**: 1144-1147. 1940.



Milk clotting and gelatin hydrolyzing activity of the leaf, stem and root of the papaya plant during the first 403 days of growth.

Table II. *Total moisture and total solids in the root, stem, and leaf of the papaya plant.*

Age in days	Total moisture			Total solids		
	Root %	Stem %	Leaf %	Root %	Stem %	Leaf %
43	86.5	92.8	87.8	13.5	7.2	12.2
73	86.5	88.3	82.5	13.5	11.7	17.5
103	88.5	90.0	84.4	11.5	10.0	15.6
133	89.0	95.5	92.3	11.0	4.5	7.7
163	89.9	86.5	66.0	10.1	13.5	34.0
193	89.7	93.5	75.0	10.3	6.5	25.0
223	90.0	88.0	75.7	10.0	12.0	24.3
253	90.5	87.2	78.8	9.5	12.6	21.2
283	91.2	87.6	79.1	8.8	12.4	20.9
313	87.0	84.9	70.2	13.0	15.1	29.8
343	88.5	80.7	71.2	11.5	19.3	28.1
373	89.9	87.5	78.8	10.1	12.5	21.2
403	87.0	86.5	78.0	13.0	13.5	22.0
Average	89.0	89.0	78.5	11.0	11.0	21.5

Table III. *Milk clotting and formol titration per cc. of leaf juice, per gram of dry leaf and per gram of fresh leaf.*

Age in days	pH of leaf juice	Milk clotting units			Formol titration cc. 0.01N NaOH		
		Per cc. of juice	Per gm. of dry leaf	Per gm. of fresh leaf	Per cc. of juice	Per gm. of dry leaf	Per gm. of fresh leaf
43	6.10	0.25	1.80	0.22	2.08	15.00	1.83
73	6.35	0.97	4.56	0.80			
103	5.77	0.76	4.10	0.64	6.18	33.37	5.22
133	5.70	0.93	11.16	0.86	4.68	56.16	4.32
163	6.58	3.17	6.15	0.21			
193	6.38	1.89	5.67	1.42	13.88	41.64	10.41
223	6.09	2.79	8.64	2.11	12.43	38.53	9.41
253	5.78	1.28	4.75	1.01	5.00	18.60	3.94
283	6.06	1.69	6.42	1.34	6.29	24.28	5.05
313	6.20	1.90	4.56	1.33	13.90	33.36	9.76
343	5.95	1.44	3.60	1.03	11.20	28.00	7.90
373	5.90	1.48	5.48	1.17	7.90	29.23	6.23
403	5.98	1.30	4.68	1.01	3.78	13.61	2.95
Average	6.06	1.53	5.50	1.01	7.95	30.15	6.09

Table IV. *Milk clotting and formol titration per cc. of stem juice, per gram of dry stem and per gram of fresh stem.*

Age in days	pH of stem juice	Milk clotting units			Formol titration cc. 0.01N NaOH		
		Per cc. of juice	Per gm. of dry stem	Per gm. of fresh stem	Per cc. of juice	Per gm. of dry stem	Per gm. of fresh stem
43	5.75	0.00	0.00	0.00	0.47	6.06	0.44
73	5.80	0.09	0.68	0.08			
103	5.40	0.11	0.99	0.10	1.00	9.00	0.90
133	4.30	0.24	5.09	0.23	0.40	8.48	0.38
163	5.50	0.27	1.73	0.23			
193	5.88	0.35	5.04	0.33	0.68	9.79	0.67
223	5.46	0.46	3.36	0.41	1.25	9.13	1.10
253	5.31	0.42	3.17	0.37	1.30	8.97	1.14
283	5.58	0.49	3.96	0.43	1.86	13.21	1.63
313	5.60	0.34	1.90	0.29	1.88	10.53	1.60
343	5.62	0.32	1.35	0.26	0.77	3.23	0.62
373	5.55	0.33	2.31	0.29	1.20	8.40	1.05
403	5.55	0.43	2.75	0.37	0.50	3.20	0.43
Average	5.48	0.30	2.48	0.26	1.03	8.18	0.91

Table V. *Milk clotting and formol titration per cc. of root juice, per gram of dry root and per gram of fresh root.*

Age in days	pH of root juice	Milk clotting units			Formol titration cc. 0.01N NaOH		
		Per cc. of juice	Per gm. of dry root	Per gm. of fresh root	Per cc. of juice	Per gm. of dry root	Per gm. of fresh root
43	5.90	0.00	0.00	0.00	0.55	3.52	0.48
73	5.84	0.03	0.19	0.03			
103	5.93	0.09	0.69	0.08	0.68	5.24	0.60
133	5.00	0.09	0.73	0.08	0.55	4.45	0.49
163	5.47	0.07	0.62	0.06			
193	5.62	0.16	1.39	0.14	0.73	6.35	0.66
223	5.50	0.31	2.79	0.28	1.43	12.90	1.24
253	5.55	0.17	1.61	0.15	1.00	9.50	0.91
283	5.55	0.33	3.43	0.30	1.68	17.50	1.53
313	5.50	0.29	1.94	0.25	1.33	8.90	1.16
343	5.55	0.25	1.92	0.22	1.28	9.84	1.14
373	5.55	0.20	1.78	0.18			
403	5.28	0.16	1.07	0.14	0.50	3.34	0.44
Average	5.56	0.17	1.39	0.15	0.97	8.12	0.87

Table VI. *Milligrams of nitrogen per gram of fresh and dry leaf, stem, and root.*

Age in days	Milligrams of N per gram of fresh tissue			Milligrams of N per gram of dry tissue		
	Leaf	Stem	Root	Leaf	Stem	Root
43	5.6	1.3	2.0	47.7	18.4	14.5
73	7.9	1.5	2.5	45.0	12.4	18.4
103	6.0	1.8		38.5	18.2	
133	2.9	0.7	2.1	38.0	15.2	18.7
163	15.2	2.5	1.5	44.8	18.5	14.4
193	8.9	0.8	1.3	35.6	13.0	13.3
223	10.8	1.6	2.0	44.3	13.4	19.8
253	10.6	2.6	1.5	49.9	20.8	15.8
283	9.2	1.6	1.5	44.2	13.0	16.7
313	12.7	1.4	1.3	42.5	9.0	10.0
343	13.0	1.8	1.1	46.5	9.4	9.4
373	8.4	1.2	0.9	39.8	9.9	8.5
403	8.7	0.9	1.6	39.3	6.6	12.6
Average	9.2	1.5	1.6	42.6	13.7	14.3

Table VII. *Total moisture and total solids in the rind and pulp of papayas of different inflorescences.*

Inflorescence (From top to bottom)	Rind		Pulp	
	Total moisture %	Total solids %	Total moisture %	Total solids %
7 younger	92.4	7.6	90.9	9.1
6	89.1	10.9	92.4	7.6
5	88.8	11.2	91.5	8.5
4	87.9	12.1	91.5	8.5
3	90.0	10.0	92.3	7.7
2	88.6	11.4	93.5	6.5
1 older	85.6	14.4	90.4	9.6
Average	88.9	11.1	91.8	8.2

Table VIII. *Milk clotting and formol titration per cc. of fruit rind juice, per gram of dry fruit rind and per gram of fresh fruit rind.*

Inflorescence (from top to bottom)	pH of juice	Milk clotting units			Formol titration cc. 0.01N NaOH		
		Per cc. fruit rind juice	Per gm. dry rind	Per gm. fresh rind	Per cc. fruit rind juice	Per gm. dry rind	Per gm. fresh rind
7 younger	5.38	1.83	22.3	1.69			
6	5.33	1.60	13.2	1.43	2.94	24.2	2.62
5	5.28	2.28	18.0	2.03	3.41	26.9	3.03
4	5.28	4.00	29.2	3.52	3.39	24.8	2.98
3	5.15	10.45	94.1	9.41	4.01	36.1	3.61
2	5.28	5.93	46.3	5.25	3.52	27.5	3.12
1 older	5.08	5.13	30.3	4.39	3.22	19.0	2.76
Average	5.25	4.46	36.2	3.96	3.42	26.4	3.02

Table IX. *Milk clotting and formol titration per cc. of fruit pulp juice, per gram of dry fruit pulp and per gram of fresh fruit pulp.*

Inflorescence (From top to bottom)	pH of juice	Milk clotting units			Formol titration cc. O.OIN NaOH		
		Per cc. fruit pulp juice	Per gm. of dry pulp	Per gm. fresh pulp	Per cc. fruit pulp juice	Per gm. of dry pulp	Per gm. fresh pulp
7 younger	5.53	0.30	3.0	0.27			
6	5.53	0.56	6.8	0.52	1.03	12.5	0.95
5	5.65	0.28	3.0	0.26	0.73	7.9	0.68
4	5.49	0.25	2.7	0.23	0.67	7.2	0.61
3	5.43	0.65	7.7	0.60	1.15	13.7	0.11
2	5.70	0.00	0.0	0.00	0.82	11.7	0.77
1 older	5.45	0.00	0.0	0.00	1.52	14.3	1.37
Average	5.53	0.29	3.3	0.27	0.85	9.9	0.75

Table X. *Milligrams of nitrogen per gram of fresh and dry fruit rind and pulp.*

Inflorescence (From top to bottom)	Milligrams of N per gram of fresh tissue		Milligrams of N per gram of dry tissue	
	Rind	Pulp	Rind	Pulp
7 younger	2.5	2.1	38.2	22.9
6	2.3	1.5	25.4	16.5
5	2.7	1.4	30.3	15.5
4	2.8	1.3	31.7	13.9
3	3.1	1.2	34.2	13.1
2	2.7	1.0	30.5	10.2
1 older	1.6	1.1	18.1	11.9
Average	2.7	1.4	29.9	14.9

Table XI. *Distribution of Proteolytic Activity and Nitrogen in the Papaya Plant.*

Part of the plant	Proteolitic activity per gram of dry tissue		Milligrams of nitrogen per gram of dry tissue
	Milk clotting units	cc. 0.01N NaOH	
Seed	0.00	———	41.5
Root (Average 13 months)	1.39	8.12	14.3
Stem (Average 13 months)	2.48	8.18	13.7
Fruit pulp (Average 1st to 7th inflorescence)	3.30	9.90	14.9
Leaf (Average 13 months)	5.50	30.15	42.6
Fruit rind (Average 1st to 7th inflorescence)	36.20	26.40	29.9

THE EFFECT OF STAKING AND PRUNING ON TOMATO PLANTS

By Arturo Riollano

Staking and pruning tomato plants has been a general practice among the majority of the farmers devoted to truck or market gardening in various sections of Puerto Rico. While numerous trials have been carried elsewhere to determine the relative value of these practices, experimental evidence is lacking for this Island. These trials were established to determine the effects of staking and pruning Marglobe tomato plants on yields, size, quality, and earliness of fruits under prevailing conditions at the Isabela Irrigation District. It is hoped that the information presented in this paper will be in general applicable to other sections of the Island or, at least, that it will induce some vegetable growers to make more careful observations as to the relative merits of pruning and training tomato plants in their respective areas.

Materials and Methods

Two trials were conducted on Coto Clay soil with the Marglobe variety at the Isabela Substation during the fiscal year 1936-37. This variety of tomatoes is grown almost exclusively in Puerto Rico, either for the local market or for shipping to the Continent during the winter season. The first trial was started on August 1936 with four treatments, namely, (a) unstaked, (b) staked, (c) unstaked and pruned, and (d) staked and pruned. Each treatment was replicated nine times in randomized blocks. The land used for this trial was prepared for surface irrigation by the furrow system commonly known as the Hawaii system. Seed was sown on August 20 in seedbeds made in the open and the seedlings transplanted to the field on September 19. Plants were set by hand 2½ x 4 feet apart. Square plots 1/100th acre in area were used. Thirty-five plants were set in each plot. 8-10-15 fertilizer was applied to the furrow at the rate of one ton per acre five days before transplanting. Irrigation was applied at the

approximate rate of one acre-inch once a week whenever rainfall was less than one inch in the preceding week. A total of six applications of artificial irrigation were made while the amount of natural rainfall amounted to 13.7 inches during the crop.

In all the staking treatments each plant was tied to a wooden stake driven into the ground about 10 inches and extending from 5 to 6 feet above the ground. Tying of the plants to the stakes was done with manila hemp twine. Six times during the season this operation was practiced in order to keep plants properly tied to the stakes.

In the pruning treatments, plants were pruned to a double stem and small shoots were removed as often as necessary. Pruning was done at weekly intervals and this operation was practiced 6 times during the crop. Eight applications of Bordeaux mixture 2-3-50 plus 2 lbs. of lead arsenate were made at weekly or ten-day intervals for the control of diseases and insects. Seven pickings of fruits were made: the first on November 20 and last on December 28.

Fruit from each plot was counted and classified by weight as follows: large, weighing above .3 pound; medium, weighing from .2 to .3 pound; and small, weighing less than .2 pound. Fruit with blemishes, malformations, disease symptoms or too small for marketing purposes was classified as unmarketable. The fruit was harvested green or just begining to turn, a stage of maturity considered safe for long distance shipment.

The second trial was established in another field after the results of the first trial were known. It was started on January 17, 1937, the first picking being made on April 6 and the last on May 19. A similar procedure was followed except that only two treatments were included, staked and unstaked, and that each treatment was replicated 8 times. This second test was carried out during the dry season and consequently 10 applications of irrigation water were made when rainfall dropped to 8.25 inches during the crop season.

The results of the first trial were calculated by Fisher's (3) method of statistical analysis while those of the second trial were analyzed by Student's method using Love's (5) modification. In the latter case odds greater than 30:1 are considered significant.

Results

The results are presented in detail in tables 1 and 2. They have been reported in hundredweights per acre to facilitate the making of compari-

TABLE 1. *Effect of staking and pruning tomato plants on yield, size, and quality of fruit. First Trial.*

TREATMENT	LARGE	MEDIUM	SMALL	MARKETABLE FRUITS	CULLS	TOTAL YIELD
	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)
Unstaked	16.1	57.0	18.3	91.4	10.6	102.0
Staked	12.3	44.5	16.6	73.4	7.3	80.7
Unstaked and pruned	7.4	32.2	15.0	54.6	9.1	63.7
Staked and pruned	5.0	29.3	12.0	46.3	5.8	52.1
Difference for significance at 5 per cent point	2.5	14.4	2.9	7.4	2.5	8.2
Difference for significance at 1 per cent point	3.4	19.6	3.9	10.8	3.4	11.1

TABLE 2. *Effect of staking tomato plants on yield, size, and quality of fruit. Second Trial. Yields are given in hundredweights per acre.*

TREATMENT	LARGE	MEDIUM	SMALL	MARKETABLE FRUITS	CULLS	TOTAL YIELD
	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)
Unstaked	52.9	66.6	19.0	138.5	17.2	155.7
Staked	43.6	57.1	15.7	116.4	11.8	128.2
Loss by staking	9.3	9.5	3.3	22.1	5.4	27.5
Per centage loss	17.5	14.3	17.4	16.0	31.4	17.4
Student's odds [1]	216:1	70:1	59:1	1999:1	184:1	1428:1

[1] Odds greater than 30:1 are considered significant.

sons in terms used by local growers. Yields obtained in these trials seem to be low if compared to those obtained in the Continent. However, these yields compare favorably with those reported by Colón Torres and Morales (1) as obtained by commercial growers in the Jayuya section of this Island.

In both trials staking reduced consistently and significantly yields of all classes of fruit when compared with the unstaked treatments. The effect of staking on total yield is decidedly detrimental when considering that this practice caused an average loss of 21.3 hundredweights of fruit per acre in the first trial and 27.5 hundredweights in the second trial. Staking increases slightly the percentage of marketable fruit but reduces greatly total yields. The apparent effect of staking upon quality of fruit is offset by the marked reduction on total yields of marketable fruit. Thus it will be observed that staking reduced the yield of marketable fruit by 18.0 hundredweights in the first trial and by 22.1 hundredweights in the second trial.

The combination of pruning and staking seems to reduce further, in a significant way, the yields of all classes of fruit. The unstaked and pruned treatment was inferior to the staked or unstaked treatment, but it was superior to the staked and pruned treatment where the lowest yields were recorded. The descending order of merit of marketable yields for unstaked, staked, and unstaked and pruned, staked and pruned will, therefore, run as follows: 91.4, 73.4, 54.6 and 46.3 hundredweights per acre respectively. For total yield the same trend is observed for the above treatments, namely, 102.0, 80.7, 63.7, and 52.1 hundredweights per acre, respectively. Considering total yields of marketable fruit, the effects of pruning and staking upon quality are significantly undesirable.

The average weight of all fruit harvested from the different treatments in both trials has been presented in table 3.

TABLE 3. *The effect of staking and pruning on size of fruit. Average weight of fruit by trials and treatments.*

	UNSTAKED	STAKED	UNSTAKED & PRUNED	STAKED & PRUNED
	(lbs.)	(lbs.)	(lbs.)	(lbs.)
First trial	0.233	0.234	0.215	0 213
Second trial	0.278	0.255		

In spite of the apparent tendency to reduce size of fruit when pruning or staking was practiced, the differences in weight recorded were not sig-

nificant. Furthermore, these differences in size must be larger in order to be of any commercial value.

The effect of staking and pruning on earliness may be studied by observing the total yields obtained with the different treatments in the first four pickings. In the first trial, as illustrated in figure 1 and table 4, it seems that pruning without staking had some favorable effect on the quantity of early fruit set by causing slightly higher yields in the

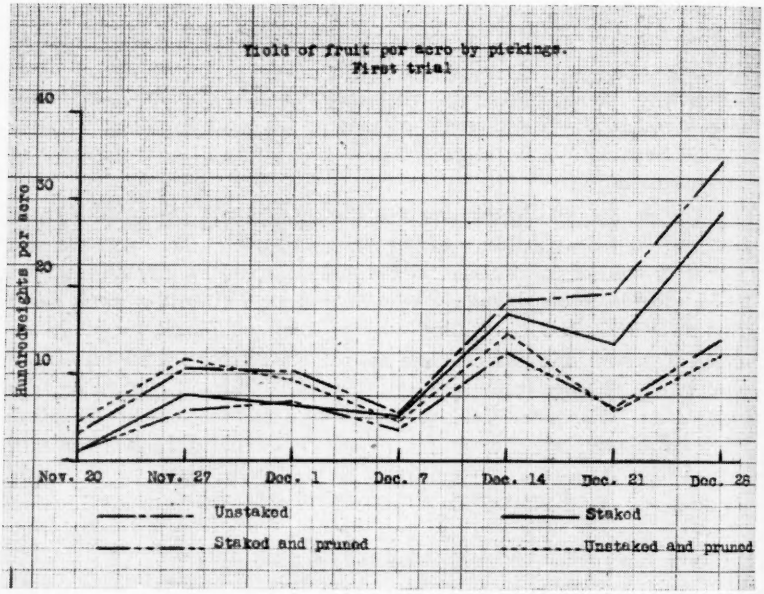


Fig. 1. *The effects of pruning and staking on total yields and earliness of fruit.*

pickings of November 20 and 27. When considering total yields of the first four pickings, the unstaked plots whether pruned or unpruned, were not statistically different, but each outyielded in a significant way the other two treatments. In the second trial where pruning treatments were omitted, the unstaked treatment with 106.6 hundredweights per acre in the first four pickings, had a marked and significant effect upon the quantity of early fruit set when compared with the staked treatment which produced only 75.1 hundredweights of fruit per acre during the same

TABLE 4. *Effect of staking and pruning on earliness. First Trial. Yields in hundredweights per acre by pickings.*

DATE	UNSTAKED	STAKED	UNSTAKED & PRUNED	STAKED & PRUNED	DIFFERENCE FOR SIGNIFICANCE
	(100 lbs.)	(100 lbs.)	(100 lbs.)	(100 lbs.)	
November 20	3.3	1.3	4.2	1.4	
November 27	10.5	7.6	11.5	6.3	
December 1	10.3	6.8	9.7	7.1	
December 7	5.7	5.3	4.9	3.9	
Yields per acre first four pickings, 9 replicates	29.8	21.0	30.3	18.7	3.5 * 4.8 **
December 14	18.4	17.3	14.8	12.7	
December 21	19.3	13.7	6.3	6.5	
December 28	34.5	28.7	12.3	14.2	
Totals	102.0	80.7	63.7	52.1	8.2 * 11.1 **

* Significance at 5 per cent point.
** Significance at 1 per cent point.

TABLE 5. *Effect of staking on earliness. Second Trial. Yields in hundredweights per acre by pickings.*

DATE	UNSTAKED	STAKED	STUDENT'S ODDS
	(100 lbs.)	(100 lbs.)	
April 6	9.8	6.5	
April 14	31.6	19.0	
April 21	36.6	27.5	
April 28	28.6	22.1	
Yields per acre first four pickings. 8 replicates	106.6	75.1	4999:1
May 5	22.8	25.3	
May 12	13.4	14.4	
May 19	12.9	13.4	
Totals	155.7	128.2	1428:1

period of time. The results of both trials as shown in tables 4 and 5, indicate that staking is responsible for a significant reduction in the quantity of early fruit set.

Considering only the staked and unstaked treatments in both seasons, it will be observed in figures 1 and 2 that higher yields, regardless of treatment, were obtained during the last three pickings in the first trial which was established on August 1936; while in the second trial which

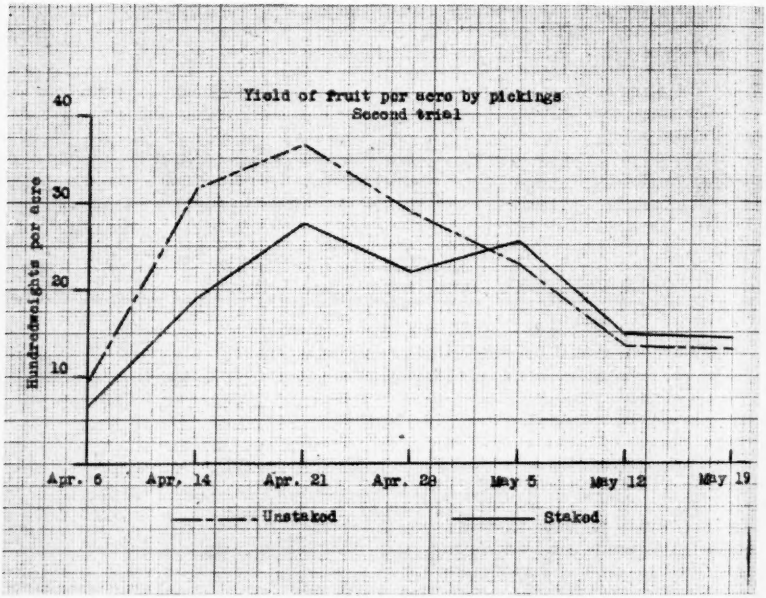


Fig. 2. *The effects of staking on total yields and earliness of fruit.*

was started on January 1937, the lowest yields were recorded in the last three pickings with the exception of the fifth picking of May 5th in the staked plots. This contrasted trends of yields might be attributed to seasonal effect.

Discussion and Summary

The fact that these trials were established under irrigation by the furrow system must be clearly emphasized. In this way it seems that

the possibilities of increasing the amount of unmarketable fruit in the unstaked plants are greatly favored because a large percentage of the fruit clusters lie in direct contact with the water soaked soil when irrigation is practiced. The main argument offered by vegetable growers who stake and prune their tomatoes is that such cultural methods tend to increase marketable yields because the fruit clusters develop high above the soil, free from dirt. Nevertheless, the two trials conducted at the Isabela Substation show conclusively that pruning and staking tomato plants reduce considerably yields of marketable and total amount of fruit as long as the same number of plants are kept constant in the different practices compared. These results are in accord with the abundant evidence presented by Thompson (7) on these practices with trials he conducted in New York State and with the profuse literature he has reviewed on this subject. In the trials conducted in Australia Strickland (6) concluded that staking and pruning of unstaked plants were of doubtful value, except on limited areas.

However, the apparent conflicting results reported by other workers are due mainly to the use of less space or more plants per acre for the pruning and staking practices as compared to the untreated plots or, probably, to the wide variations in environmental conditions under which the different trials were established. Conflicting results may also follow according to Currence (2) when different varieties of tomatoes are subjected to pruning and training. He found that pruning was beneficial to Break O'Day variety and apparently detrimental to Pritchard. Even assuming that pruning and staking with twice the number of plants per acre as compared to the untreated plants, would produce equal or larger amounts of marketable fruit, the profitableness of such practices is still questionable. The added expenses involved in setting more plants per acre plus the cost of stakes, training and pruning several times during the crop, must be also considered before drawing general conclusions on the advisability of such cultural methods.

Pruning and staking had no favorable effects on the size and earliness of fruit in these two trials. In the second trial staking caused a significant decrease on the quantity of early fruit set when compared with the untreated plots. Earliness is not considered an important factor in Puerto Rico where tomatoes are grown successfully at any time of the year.

Hawthorne (4) has reported in Texas an increase in the amounts of early marketable yields from the first four pickings of pruned unstaked plants. This contrast with our results might be explained by the effect

of differences in climatic conditions. However, he found that when yields of the entire crop were considered, the unpruned plants resulted with the highest yields. Hawthorne also did not find any effect of pruning on size of fruit.

In conclusion, it may be stated that the results of our trials with pruning and staking Marglobe tomato plants plus the cumulative evidence from similar experiments conducted elsewhere, seem to indicate that such cultural methods are not conducive to the highest yields of marketable fruit. Pruning and staking under our climatic conditions have a tendency to decrease total marketable yields while not affecting favorably size, quality nor earliness of fruit.

SUMARIO EN ESPAÑOL

ESTAQUEO Y PODA DE LOS TOMATES

El estaqueo y la poda en los tomates han sido prácticas muy generalizadas entre los agricultores que se dedican a la producción de hortalizas en Puerto Rico. Se cree que con estas prácticas se aumenta la producción y se consigue una proporción más alta de fruta de mejor calidad para la exportación o para el mercado local.

Con el fin de obtener información sobre el particular, se establecieron dos experimentos con tomates bajo regadío en la Subestación Experimental de Isabela en donde se compararon los siguientes tratamientos: (a) testigo sin estaqueo o poda, (b) estaqueo sin poda, (c) poda sin estaqueo y (d) estaqueo con poda. Se utilizó el mismo número de plantas de la variedad "Marglobe" en cada tratamiento y se tomaron las precauciones necesarias para que todos los tratamientos con ocho y nueve repeticiones recibieran atención uniforme.

Los resultados de la primera prueba indicaron que el estaqueo redujo la producción total de fruta comercial en un 20 por ciento aproximadamente y cuando se practicó la poda sin estaqueo, esta reducción llegó a un 40 por ciento comparado con el testigo sin poda ni estaqueo. Además, cuando se estaqueó y se podó, la reducción fué aún mucho mayor ya que la producción total bajó al 50 por ciento aproximadamente comparado con el testigo. En la segunda prueba en que se sometió la poda, se encontró que el estaqueo redujo la producción de fruta comercial en un 22 por ciento. Aunque el estaqueo en ambas pruebas causó un pequeño aumento en la proporción de fruta comercial, esta ventaja aparente quedó compensada por los efectos en la reducción total de fruta producida. En otras palabras, cuando no se estaqueó ni se podó, se produjo una mayor proporción de rezagos o fruta inservible para la venta; pero como la producción total de fruta aumentó grandemente, el total de fruta comercial producida fué entonces mucho mayor que cuando se estaqueó o se podó.

Ni el estaqueo ni la poda tuvieron efectos favorables en cuanto al tamaño de la fruta o la producción de una cosecha temprana se refiere. En términos generales estos resultados coinciden con los obtenidos en numerosas pruebas que se han llevado a cabo en diversas regiones de los Estados Unidos y en Australia. En conclusión puede decirse que nuestras pruebas de estaqueo y la poda en los tomates de la variedad "Marglobe", unida a la evidencia acumulada en pruebas efectuadas en otros sitios, demuestran que estas prácticas son perjudiciales ya que disminuyen la producción comercial del fruto y aumentan considerablemente los gastos de la cosecha.

STUDIES OF THE SHADE REQUIREMENTS OF VANILLA

by

Ernesto Hernández Medina
Puerto Rico Experiment Station
of the
U. S. Department of Agriculture
Mayagüez, P. R.

INTRODUCTION

The vanilla of commerce [*Vanilla fragrans* (Salisb.) Ames] requires considerable shade for its best development. In existing vanilleries in Puerto Rico this shade is provided either by the use of the dwarf bucare (*Erythrina berteroana* Urban), which also serves as a support tree or by existing shade trees such as the guaba (*Inga vera* Willd.), and the guamá [*Inga laurina* (Sw.) Willd.]

Newport (5) states that the shade necessary for vanilla is not dense but rather chequered. According to Galbraith (2) in selecting trees for shade those should be chosen which give moderate to about half shade and which do not shed their leaves all at once. Chalot (1) points out the fact that weight and aroma of the beans are greatly influenced by the degree of sunlight to which the vines are exposed. Meinecke (4) states that in general the vanilla vine demands a little more sunlight than shade especially during the flowering season and at the time the beans are maturing. According to McClelland (3) the character of growth of vanilla vines depends greatly on the amount of shade to which the vines are exposed.

From the literature cited it is evident that some shade is essential for vanilla. Since no record could be found as to the exact amount required, an experiment was conducted at the Puerto Rico Experiment Station to determine this by observing the behavior of the vines when planted under different exposures to sunlight.

EXPERIMENTAL PROCEDURE

The field used for this experiment had a gentle slope and the soil was a Catalina clay. Drainage ditches in lengthwise and crosswise directions divided the field into 16 contiguous plats each measuring 30 by 20 feet.

The four light exposures tested were as follows: full sunlight, two-thirds sunlight, one-half sunlight, and one-third sunlight. Exposures to light less than full were provided by overhead and side bamboo laths appropriately spaced. Each light treatment was replicated 4 times, and there were 30 plants in each replicate making a total of 120 plants per treatment or 480 plants in the entire experiment. Eight-node vanilla cuttings selected for uniform size and vigor were planted at the base of non-living support stakes. The usual mulching practice for vanilla was followed throughout.

All cuttings were planted on October 9, and every 3 months thereafter data were taken on root formation, seed-piece rotting, and vegetative growth. In addition, the condition of the vines at the termination of the experiment as well as their weights and the number of eight-node cuttings obtained were used to evaluate the various light treatments.

EXPERIMENTAL RESULTS

Root Formation

With respect to the number of roots formed, it was found that the vines planted under one-third sunlight consistently produced the greatest

Table 1. *Cumulative root formation on vanilla cuttings planted under four exposures to light, Mayagüez, October 9, 1940.*

Treatment (Exposure to light)	Roots formed [1]			
	Jan 9	April 9	July 9	Oct. 9
	Number	Number	Number	Number
Full sunlight	300	[2] 93	[2] 58	[2] 53
⅔ sunlight	352	[2] 319	[2] 303	[2] 300
½ sunlight	394	410	449	472
⅓ sunlight	428	451	498	[2] 490

1 On 120 8-node cuttings planted in each treatment.

2 Decrease due to decay of some roots previously formed.

number of roots, while the vines planted under full sunlight produced the least. The data for root formation are presented in table I.

It is interesting to note that the number of roots formed on the cuttings of each treatment was inversely proportional to the degree of sunlight to which the cuttings were exposed.

Seed-piece Rotting and Stem Growth of Vines

The data pertaining to seed-piece rotting and stem growth of vines were very interesting. The cuttings grown under one-half and one-third normal sunlight suffered the least amount of stem rotting. In addition, they produced consistently the greatest amount of stem growth. Although the difference between these two treatments was in favor of the vines grown under one-third normal sunlight it was by no means considerable. These results are shown in table II.

As shown in table 2 the vines exposed to full sunlight and two-thirds sunlight sustained the greatest amount of seed-piece rotting and produced the least amount of stem growth. It is clearly seen that the extent of rotting of the seed-pieces was in direct proportion to the degree of sunlight they received, namely, the less the sunlight the lower the percentage of rotting of the seed-pieces. In the case of the stem growth made by the cuttings the reverse was true, that is, the amount of vegetative growth was in inverse proportion to the exposure to light.

Figure 1 shows the cumulative amount of stem growth made by the vines under the different exposures to light at each recorded reading, together with the amount of rainfall measured between readings.

It is evident from figure 1 that at each recorded reading there was no great difference in amount of vegetative growth between the cuttings grown under one-half sunlight and those grown under one-third sunlight. However, there were considerable differences in this respect which were statistically significant between the two treatments of more and less than one-half sunlight. It is of interest to note in figure 1 also that the greatest amount of vegetative growth between readings occurred during periods of abundant rainfall.

Condition of Vines and Weight and Number of Cuttings

At the termination of the experiment the condition of the vines under the various exposures to light was recorded to determine how the various

Table 2. *Extent of rooting and stem growth made by vanilla cuttings planted under four exposures to light, Mayagüez, October 9, 1940.* [1]

Treatment (Exposure to light)	January 9		April 9		July 9		October 9		January 9	
	Internodes decayed	Stem growth	Internodes decayed	Stem growth	Internodes decayed	Stem growth	Internodes decayed	Stem growth	Internodes decayed	Stem growth
	Percent	Feet	Percent	Feet	Percent	Feet	Percent	Feet	Percent	Feet
Full sunlight	18.6	0.62	66.7	1.54	83.3	2.41	89.5	2.34	92.1	5.89
⅔ sunlight	1.5	0.80	13.5	2.36	35.7	5.07	38.1	9.73	44.3	16.17
½ sunlight	1.4	1.13	2.3	3.45	3.2	7.81	4.8	15.76	7.7	22.67
⅓ sunlight	0.01	1.13	1.3	3.52	2.0	8.27	4.2	15.90	7.1	23.94

[1] On 120 8-node cuttings planted in each treatment. Data are cumulative.

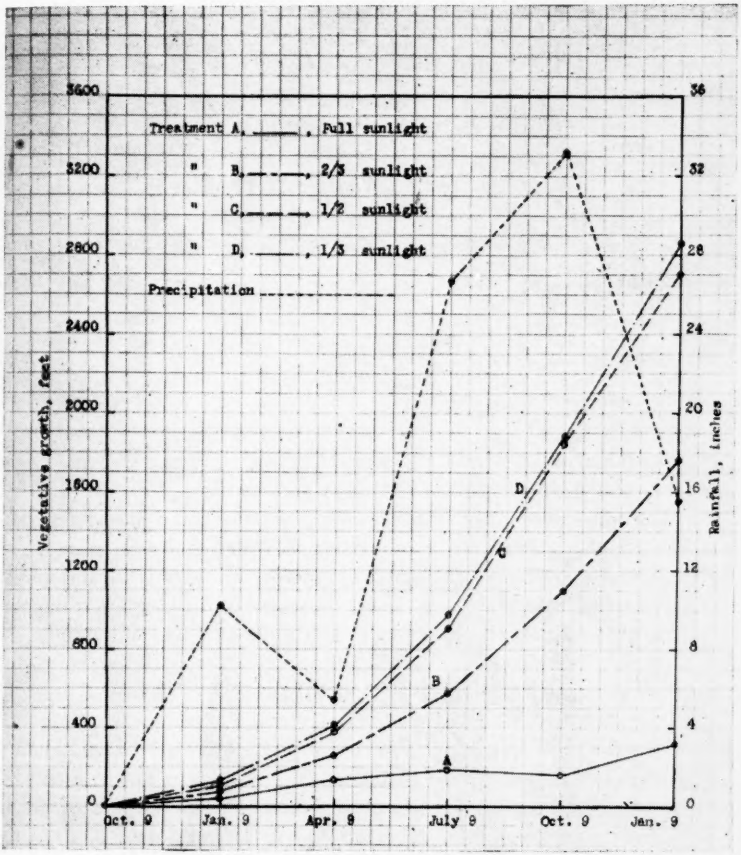


Figure 1. *Vegetative growth made by vanilla cuttings at 3-month periods when grown under four exposures to sunlight, together with the amount of rainfall between readings.*

degrees of sunlight had affected the development of the vines. This information is summarized in table 3 together with the weight of the vines and number of eight-node cuttings obtained from those grown in each treatment.

The vines grown under one-half and one-third normal sunlight produced the highest percentages of healthy plants and the least percentages

Table 3. *Condition of vanilla plants at end of 15 months planted under four exposures to light, together with weight of vines and number of 8-node cuttings per treatment.*

Treatment (exposure to light)	Condition of plants			Weight of vines	Eight-node cuttings
	Healthy	Wilted	Dead		
	Percent	Percent	Percent	Pounds	Number
Full sunlight	32.5	16.7	50.8	26.8	142
⅔ sunlight	84.2	5.0	10.8	201.0	713
½ sunlight	98.3	0.0	1.7	344.0	975
⅓ sunlight	96.6	1.7	1.7	366.0	963

of wilted and dead plants. The same vines also produced the highest weights and greatest numbers of eight-node cuttings.

The vines grown under full sunlight produced the lowest proportion of healthy plants and highest proportion of wilted and dead plants. It is evident that there were considerable differences in the weights and numbers of eight-node cuttings between the vines exposed to the two lowest exposures to sunlight and those exposed to the two highest degrees of sunlight.

CHARACTER OF GROWTH OF VINES

Since the beginning of the experiment it was observed that the character of growth of the vines varied with the exposure to light to which they were exposed. The vines exposed to one-third and one-half the normal sunlight developed more vigorously, as illustrated in figure 2 and 3, than those exposed to two-thirds and full sunlight, as illustrated in figures 4 and 5. Moreover, the former were of a dark green color and their internodes longer and thicker, as compared to the yellow to yellowish-green and shorter and thinner internodes of the vines exposed to full and two-thirds sunlight.

SUMMARY

The work here reported showed that the vanilla plant requires considerable shade for its best development. When vanilla was grown under four exposures to light it was found that the best vine growth from the

Figure 2. *Typical plants of Vanilla fragrans grown under one-third sunlight at the end of 15 months. Note the vigorous condition of the vines and the thick and long internodes. The vines were of a rich dark-green color.*

Figure 3. *Typical plants of Vanilla fragrans under one-half sunlight at the end of 15 months. The vines were vigorous and had long thick internodes, but the color was somewhat lighter than that of vines exposed to one-third normal sunlight.*

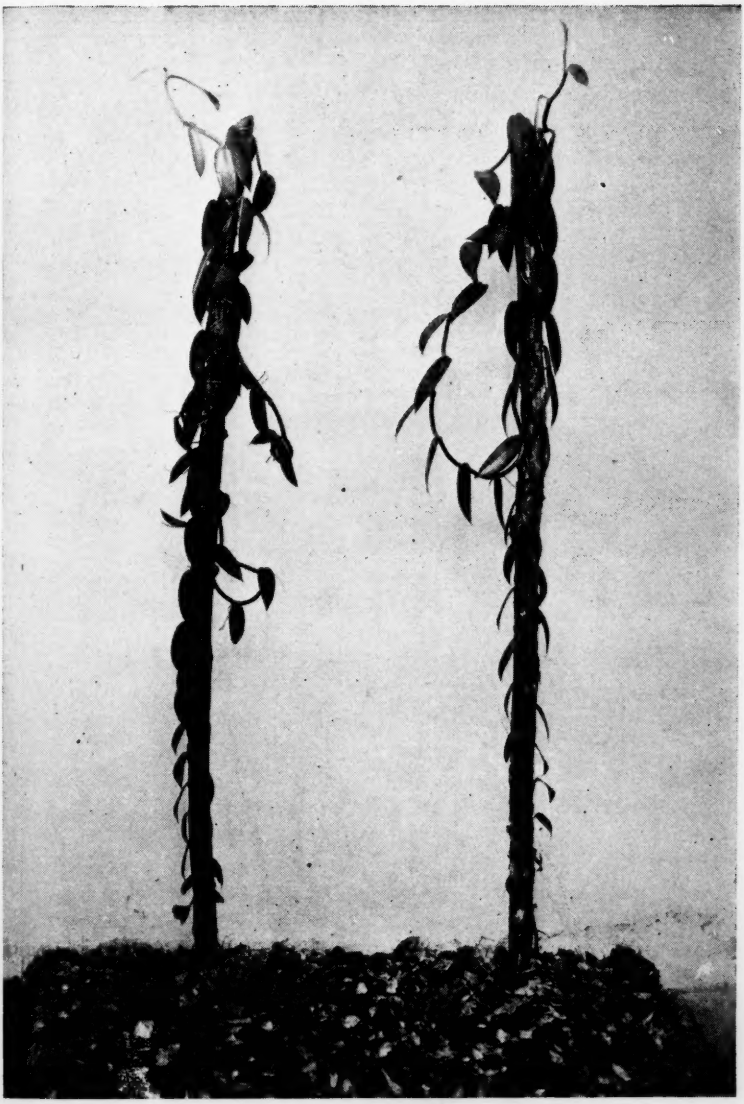


Figure 4. *Typical plants of Vanilla fragrans grown under two-thirds sunlight at the end of 15 months. These vines were considerably less vigorous than those shown in figures 2 and 3. Also the internodes were shorter and thinner. The color was yellowish-green.*

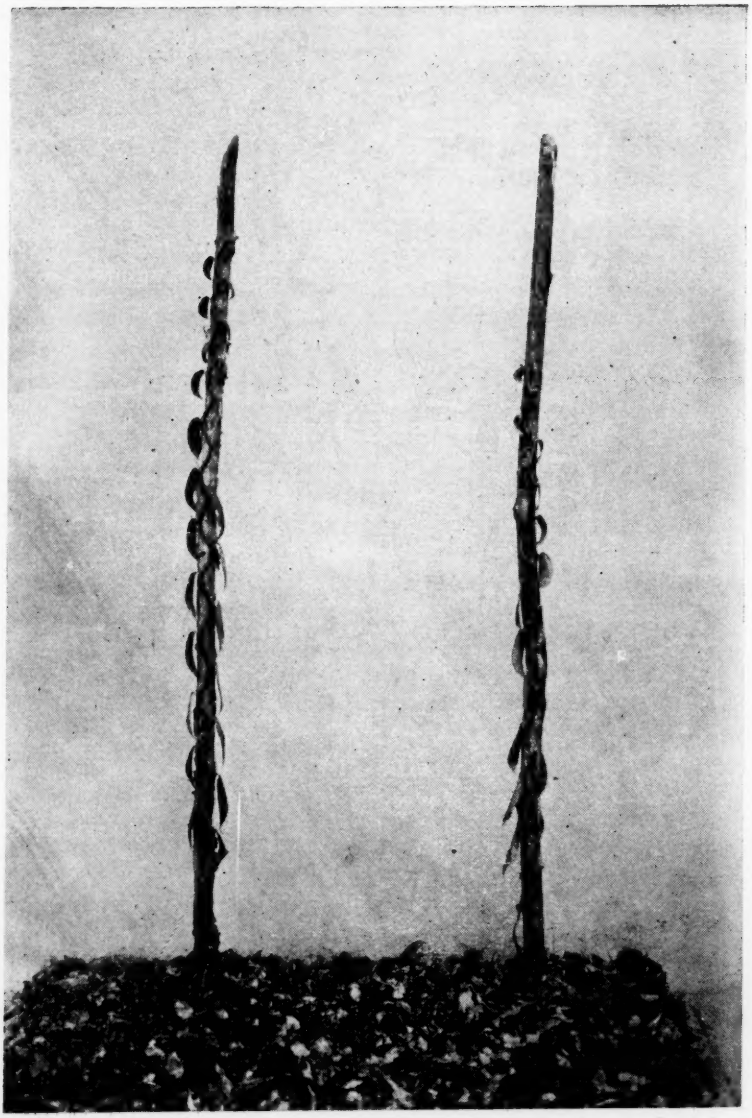


Figure 5. *Typical plants of Vanilla fragrans grown under full sunlight at the end of 15 months. Note the drooping leaves and short internodes. Vines were yellow-green, almost chlorotic in color.*

standpoint of root germination, seed-piece rotting, and vegetative growth was accomplished under shade conditions which admitted from one-third to one-half the normal sunlight when the sun was directly overhead. The most vigorous and greatest weight of vines and the greatest number of eight-node cuttings were also obtained under those conditions.

SUMARIO

Se indica en estudios sobre desarrollo vegetativo que la vainilla requiere abundante sombra. Sembrándose bajo cuatro distintas proporciones de sombra se notó el mejor desarrollo de las plantas cuando se sombreó en tal forma que se admitiera una tercera parte o una mitad de la cantidad de luz solar. Este desarrollo se expresó en producción de raíces, tallo y baja podredumbre de los esquejes. El mejor índice de desarrollo fué el número de esquejes de ocho nudos y la lozanía de las plantas.

LITERATURE CITED

(1.) Chalot, Ch. and U. Bernard. Establissment d'une vanillerie. (Establishment of a vanillery. *In* Culture et préparation de la vanille. (Vanilla culture and curing). p. 33-43. 1920.

(2.) Galbraith, S. J. Vanilla culture as practiced in the Seychelles Islands. U. S. Dept. Agr. Bul. 21: 1-24, pl. 1, fig. 2. 1898.

(3.) McClelland, T. B. Vanilla: A promising new crop for Porto Rico. Puerto Rico (U. S.) Agr. Exp. Sta. Bul. 26: 1-32, fig. 2. 1919.

(4.) Meinecke, E. P. Les vanillières de Tahiti & de Moorea. (The vanilleries of Tahiti and Moorea). Report: 1-44. 1916.

(5.) Newport, H. Vanilla culture for tropical Queensland. Queensland Agr. Jour 24: 184-189, pl. 11, fig. 1. 1910.

Printed by
IMPRENTA VENEZUELA
E. Franklin & Co.
San Juan, Puerto Rico.